



**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460**

**OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES**

PC CODE: 032501
CHEMICAL: Disulfoton
DP Barcode: D280670

MEMORANDUM

February 25, 2002

SUBJECT: Disulfoton: Summary of Estimated Drinking Water Concentrations (EDWCs) use in the Human Health Risk Assessment.

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This memo summarizes the Tier II estimated drinking water concentrations (EDWC) for disulfoton in surface water for use in human risk assessment. Tier I ground water concentrations are also presented. The drinking water assessment considers both parent disulfoton and total disulfoton residues (TDR, the sum of disulfoton, D. sulfoxide, and D. sulfone) as these degradates were included in the HED human risk assessment. The EDWCs considered by HED in the human risk characterization (i.e., surface water peak, annual mean, and long term mean) are summarized by crop and management practice in Table 1. The parent disulfoton and TDR

concentrations for the cotton scenario are also given using the default “for all agricultural ” crops (0.87) PCA factor, because all uses have not been modeled. The cotton scenario, with the 0.87 PCA, is given as to represent an upper end exposure site.

Table 1. Tier II Estimated Drinking Water Concentrations (EDWC) for parent disulfoton and total disulfoton residues (sum of parent disulfoton and D. sulfone and D. Sulfoxide) by crop in Index Reservoir and PCA ¹ .					
Crop (PCA)	Application Rate (lb ai/A) and Method	Number of Applications/ Interval (days)	Concentration (µg/L)		
			Peak parent/total	Annual Average parent/total	Long-term Average parent/total
Barley (0.87)	1.0 foliar	2	15.51/34.53	1.61/7.62	0.95/4.21
Barley (0.87)	0.83 granular, soil applied	2	12.96/33.96	1.06/8.70	0.44/4.72
Barley (0.87)	1.0 ² granular, soil applied	2	14.88/39.05	1.22/10.01	0.51/5.42
Cotton (0.20)	1.0 ground and soil	1	7.21/12.59	0.40/1.96	0.12/1.05
Cotton (0.87) ³	1.0 ground and soil	1	31.35/54.76	1.73/8.53	0.52/4.57
Potatoes (0.87) Western states	3.0 ground and soil	1	6.89/12.53	0.46/4.77	0.39/3.71
Potatoes (0.87) East of Rockies	1.0 foliar	3	13.09/34.37	1.09/16.72	0.94/9.49
Spring Wheat (0.56)	0.75 foliar	1	2.79/8.02	0.24/2.39	0.19/1.82

¹ PCA = 0.87 for barley and potatoes, 0.56 for spring wheat, 0.20 for cotton, and 0.87 all agricultural land. One cotton scenario the PCA is assumed to be 0.87.

² Barley with 1.0 lb ai/A application has an EDWC that is (1.0/0.87) larger than the 0.87 lb ai/A application.

³ The Agency default PCA for cotton is 0.20. Cotton without an adjustment for PCA, or 0.87, would overestimated the EDWC.

In Table 1, the peak surface water EDWC represents the upper 1-in-10-year peak event concentration, the surface water annual EDWC represents the upper 1-in-10 year mean annual concentration, and the long term EDWC is the overall average for the entire simulation. The EDWCs are based on linked PRZM and EXAMS models, with the Percent Crop Area (PCA) and Index Reservoir (IR), while using the label maximum rate and number of applications, and the

shortest re-application interval. Note, the cotton is shown with a PCA of 0.87 to represent an upper end exposure site. SCI-GROW and monitoring data was used to estimate ground water concentrations (Table 2).

Table 2. Ground-water concentrations.			
Method	Application rate/number ¹	Concentration (µg/L)	
		Parent disulfoton	Total Disulfoton Residues
SCI-GROW (modeled)	3.0 lb ai/ac/1	0.02	1.19
Monitoring	Mostaghimi, 1998	mean = 0.39 ² (range 0.04 to 2.87)	not measured
“	NAWQA	0.010 to 0.060	not measured
“	WI DNR	4.0 to 100.0	not measured

¹ Cotton use rate, maximum use rate for major crops.

² Overall mean of data.

The PRZM/EXAMS estimated disulfoton residue concentrations in surface water appear to be strongly related to the application rate, number of applications, application interval, and method of application and timing to application to rainfall events. Everything else being equal, several management factors had an effect on the estimated drinking water concentrations. One factor was the application rate, a second was the application method (spray drift and depth of incorporation). A third factor was the percent cropped area (PCA). These values were set as presented to the SAP (Jones and Abel, 1997; Jones et al., 2000). The application rate and PCA result in linear differences in estimated concentrations (e.g., double the rate the EDWC doubles). Increasing the depth of incorporation also lowered the EDWCs. Method of application and formulation also influenced the EDWCs; the granular formulation essentially has no spray drift while for aerial applications drift can be significant.

Summary and Conclusions:

The models used by EFED show that disulfoton and degradates will be found in runoff. Non-targeted monitoring has found disulfoton and disulfoton degradates in surface water. However, the fate of disulfoton and its degradates once in surface water and sediments, and the likely concentrations therein, cannot be modeled with a high degree of certainty since data are not available for the aerobic and anaerobic aquatic degradation rates. Surface water concentrations of disulfoton and total disulfoton residues were estimated by using linked PRZM3 and EXAMS models using several different scenarios (barley, cotton, potato, and spring wheat). The large degree of latitude available in the disulfoton labels also allows for a wide range of possible application rates, total amounts, application methods, intervals between applications and

application date(s). The relatively rapid rate of microbial degradation in the soil (<20 day aerobic soil metabolism half-life) and direct aquatic photolysis, suggests that disulfoton parent can degrade fairly rapidly in surface water. Although there is a lack of some environmental fate data for the degradates, the assessment suggests that the degradates will reach higher concentrations than the parent because they are more persistent and probably more mobile.

The estimated drinking water concentrations (EDWC) for parent disulfoton and total disulfoton residues for different crops were determined using the IR and PCA concepts (Table 1). The peak concentrations of disulfoton in the IR appear capable of being quite high, with 1-year-in 10 peak surface water concentrations of 2.79 to 15.51 µg/L and annual mean concentrations of 0.24 to 1.61 µg/L for the parent compound. The mean EDWCs of the annual means of disulfoton ranged from 0.12 to 0.95 µg/L. Although, there is a lack of some environmental fate data for the degradates, the assessment suggests that the degradates will reach higher concentrations than the parent because they are more persistent and probably more mobile. The estimated 1-in-10 year peak concentrations for the total disulfoton residues in the IR ranged from 8.02 to 34.53 µg/L and annual mean ranged from 1.96 to 16.72 µg/L, and the mean of the annual means ranged from 1.05 to 9.49 µg/L. These estimated concentrations were highly influenced by the value PCA value. The PCA values have been estimated by OPP for spring wheat (0.56) and cotton (0.20). The default for value for all agricultural land of 0.87 was used for the barley and potatoes scenarios. Better estimates of the PCA for these crops would reduce the uncertainty associated with the estimated drinking water concentrations.

The parent disulfoton and TDR concentrations for the cotton scenario are also given with all agricultural land PCA factor being factored in for one of the cotton scenarios (Table 1). Because all uses have not been modeled, the cotton scenario, the all agricultural land PCA, is given as to represent an upper end exposure site.

The EDWC values for disulfoton parent have less uncertainty than the total residue, because there is more certainty surrounding the "estimated" aerobic aquatic metabolism half-life for the estimated aerobic aquatic half-life for the total disulfoton residues. It is recommended that the Virginia data be considered in the "quantitative" drinking water assessment for ground water exposure. The Wisconsin data should be noted and addressed more qualitatively. Highly vulnerable areas, such as the Central Sand Plain, do not represent the entire use area and can probably be better mitigated or managed a local or state level. **Specifically, it is recommended that the 1.2 µg/L be used for acute and chronic exposure from ground water (see Table 2).** Based upon the fate properties of disulfoton, the sulfoxide and sulfone degradates (more persistent and probably more mobile) have a greater probability of being found in ground water. The Agency has requested more data on the mobility and persistence of the disulfoton sulfone and sulfoxide degradates. Depending upon the results of the mobility studies, a ground water study (ies) may be required to better assess the potential exposure from the degradates (and also parent).

Monitoring Data

Surface-water samples were collected in a study to evaluate the effectiveness of Best Management Practices (BMP) in a Virginia watershed. Approximately half of the watershed is in agriculture and the other half is forested. The detections of parent disulfoton in surface-water samples ranged from 0.037 to 6.11 µg/L and fell within an order of magnitude with the estimated environmental concentrations (EECs) obtained from the PRZM/EXAMS models.

The surface-water monitoring in the USGS in the NAWQA (USGS, 1998) project found relatively few detections of parent disulfoton in surface water with a maximum concentration of 0.060 µg/L. Degradates were not included in the NAWQA study. In a separate study, disulfoton degradates were, however, reported in surface water, when a rainfall event occurred following application to wheat, where fish kills occurred; pesticide residue concentrations ranged from 29.5 to 48.7 µg/L for D. sulfoxide and 0.02 to 0.214 µg/L for D. sulfone (Incident Report No. I001167-001). The wheat field was located several miles from the pond. The volume of run off water raised the level of the pond fifteen feet. The PRZM/EXAMS estimates of peak TDR correspond fairly well with the levels noted above in the fish kill incident.

EFED also made inquiries to all fifty states concerning the whether there had been any monitoring for organophosphates pesticides in ground water and surface water as part of the cumulative assessment. (http://www.epa.gov/pesticides/cumulative/pr-a-op/iii_e_3-f.pdf). The following states conducted monitoring which included parent disulfoton: HI, KS, KT, MD, MI, NE, NC, WV, WI, and WY. There were no detections reported.

Surface- and ground-water monitoring data available in STORET were evaluated in detail, but were generally not considered due to limitations associated with high detection limits and difficulty in interpreting the data. About 50 percent of the well samples reported in STORET as <1 µg/L (low range) of disulfoton residues and the other 50% were reported as < 250 µg/L (high range). Therefore, the specific concentration of the well is not indicated. The low range wells could have concentrations from zero to 0.99 µg/L), while the high range could have concentrations from zero to 249.99 µg/L. Disulfoton concentrations were simply given as less than a value. Thus, considerable uncertainty exists with respect to the STORET monitoring data.

A pilot reservoir monitoring study was initiated by USEPA Office of Pesticide Programs, Environmental Fate and Effects Division (USEPA/EFED/OPP), USEPA Office of Ground Water and Drinking Water (USEPA/ODWG/OPP), and the USGS National Water Quality Assessment (USGS/NAWQA) to assess pesticide concentrations in raw and finished drinking water. (http://www.epa.gov/pesticides/cumulative/pr-a-op/iii_e_3-f.pdf). Disulfoton, and disulfoton sulfone and disulfoton sulfoxide were included in the study. Parent disulfoton was not detected (limit of detection = 0.005 µg/L). Degradates disulfoton sulfone were detected (0.013 µg/L) in 1 of 316 samples (LOD = 0.005 µg/L) and disulfoton sulfoxide (0.006 µg/L) in 1 of 316 samples (LOD = 0.016 µg/L). While this pilot study does not allow for a definitive assessment of potential disulfoton residues in drinking water, it does show that the degradates can be found in drinking water sources. No disulfoton residues were detected in the finished water samples. More detail can be obtained from the draft Cumulative Risk Assessment for Organophosphates.

Water Resources Assessment

i. Summary and Conclusions

The Tier II modeling of disulfoton residue concentrations in surface water used the PRZM3 and EXAMS models as applied to barley, cotton, potatoes, and spring wheat, using maximum label application rates and several application methods (Table 1). The Tier II EEC assessment uses a single site, or multiple single sites, over multiple years which represents a high-end exposure scenario from pesticide use on a particular crop or non-crop use site for ecological exposure assessments. The EECs for disulfoton were generated for multiple crop scenarios using PRZM3.12 (Carsel, 1997; 5/7/98) which simulates the erosion and run-off from an agricultural field and EXAMS 2.97.5 (Burns, 1997; 6/13/97) which simulates the fate in a surface water body. Each scenario, or site, was simulated for 20 to 40 (depending on data availability) years.

The sites selected generally were the EFED (standard scenarios) to represent a reasonable “at risk” soil for the region or regions being considered. The scenarios selected represent high-end exposure sites. The sites are selected so that they generate exposures larger than for most sites (about 90 percent) used for growing the selected crops. An “at risk” soil is one that has a high potential for run-off and soil erosion. Thus, these scenarios are intended to produce conservative estimates of potential disulfoton concentrations in surface water. The crop, MLRA, state, site, and soil conditions for each scenario are given in Tables 3 and 4.

The SCI-GROW (Screening Concentration in Ground Water) screening model developed in EFED (Barrett, 1997) was used to estimate potential ground water concentrations for disulfoton parent and total disulfoton residues under “generic” hydrologically vulnerable conditions. SCI-GROW provides a screening concentration, an estimate of likely ground water concentrations if the pesticide is used at the maximum allowed label rate in areas with ground water exceptionally vulnerable to contamination. In most cases, a majority of the use area will have ground water that is less vulnerable to contamination than the areas used to derive the SCI-GROW estimate.

ii. Application Rates Used in Modeling

Disulfoton application rates (Table 1) selected for use in the modeling scenarios were based upon information submitted by the registrant, analysis conducted by BEAD, and the disulfoton (Di-Syston) labels. Three factors were considered when selecting the application rate: 1) the labels range of allowable application rates; 2) the number of applications; and 3) the application interval. The maximum rate (ounces or pounds a.i. per crop simulated), maximum number of applications, and the shortest application intervals were selected.

iii. Modeling Scenarios

Surface Water: The disulfoton scenarios (Tables 3 and 4) are representative of high run-off sites for barley in the Southern Piedmont of Virginia (MLRA 136), cotton in the Southern Mississippi Valley Silty Uplands of Mississippi (MLRA 134), potatoes in the New England and Eastern New York Upland of Maine (MLRA 144A), and spring wheat in the Rolling Till Prairie of South Dakota (MLRA 102A). The wheat scenario was selected because of high disulfoton use on wheat in South Dakota was high. Soils property data (Table 4) and planting date information were obtained from the EFED Standard Scenarios or the PRZM Input Collator (PIC) data bases (Bird et al, 1992). The Percent Crop Area (PCA) values used for the four scenarios for estimated drinking water concentrations are also given in Table 3.

Table 3. Crop, location, soil and hydrologic group for each modeling scenario.							
Crop	MLRA¹	State	Soil Series	Soil Texture	Hydrologic Group	Period (Years)	PCA²
Barley	136	VA	Gaston	sandy clay loam	C	27	0.87
Cotton	131 ³	MS	Loring	silt loam	C	20	0.20
Potatoes	144A	ME	Paxton	sandy loam	C	36	0.87
Spr.Wheat	102A	SD	Peever	clay loam	C	40	0.56

¹MLRA is major land resource area (USDA, 1981).

² PCA is the Percent Crop Area.

³Meteorological file met131.met is used in the EFED standard cotton scenario, since the weather station is closer to the simulated site then met134.met.

Table 4. Selected soil properties used modeling.					
Soil Series (MLRA)	Depth (in)	Bulk Density (g/cm³)	Organic Carbon (%)	Field Capacity (cm³/cm³)	Wilting Point (cm³/cm³)
Gaston (136)	16	1.6	1.740	0.246	0.126
	84	1.6	0.174	0.321	0.201
	50	1.6	0.116	0.222	0.122
Loring (131)	10	1.6	1.160	0.294	0.094
	10	1.6	1.160	0.294	0.094
	105	1.8	0.174	0.147	0.087
Paxton (144A)	20	1.6	2.90	0.166	0.66
	46	1.8	0.174	0.118	0.38
	34	1.8	0.116	0.085	0.035
Peever (102A)	18	1.35	1.740	0.392	0.202
	82	1.60	0.116	0.257	0.177
	50	1.60	0.058	0.256	0.176

Ground Water: The SCI-GROW (Screening Concentration in Ground Water) screening model developed in EFED (Barrett, 1997) was used to estimate potential ground water concentrations for disulfoton parent and total disulfoton residues under “generic” hydrologically vulnerable

conditions, but not necessarily the most vulnerable conditions. The SCI-GROW model is based on scaled ground water concentrations from ground water monitoring studies, environmental fate properties (aerobic soil half-lives and organic carbon partitioning coefficients-Koc's) and application rates.

iv. Modeling Procedure

Environmental fate parameters used in PRZM3 and EXAMS runs are summarized in Table 5. A site specific Index Reservoir was used for each scenario. The PRZM3 simulations were run for a period of 36 years on potatoes, beginning on January 1, 1948 and ending on December 31, 1983. Barley was run for 27 years (1956-1983) and spring wheat was run for 40 years (1944-1983). Cotton was run for 20 years of data (January 1, 1964- December 31, 1983). Scenario information is summarized in Tables 4 and 5.

Table 5. Disulfoton fate properties and values used in (PRZM3/EXAMS) modeling.		
Parameter	Value	Source
Molecular Weight	274.39	MRID 150088
Water Solubility	15 mg/l @20	MRID 150088
Henry's Law Coefficient	2.60 atm-m ³ /mol	EFED One-liner 05/21/97
Partition Coefficient (Koc)	551.5 (mean of 4)	MRID 43042500
Vapor Pressure	1.8E-04 mmHg	EFED One-liner 05/21/97
Hydrolysis Half-lives @ pH 4 pH 7 pH 9	1174 days 323 " 231 "	MRID 143405
Hydrolysis Rate Constants (needed for EXAMS derived from Hydrolysis half-lives)	K _{ah} = (negative) K _{nh} = 8.88E-05 K _{bh} = 3.58	
Aerobic Soil Half-life (Disulfoton)	6.12 days (0.113/d)	Upper 90% confidence bound on the mean of "half-lives" for the two aerobic soils tested in the laboratory. MRIDs 40042201, 41585101, 43800101
Aerobic Soil Half-life ¹ (Total Disulfoton Residues)	259.63 days (2.67E-03/d)	Upper 90% confidence bound on the mean of half-lives for the two aerobic soils tested in the laboratory. MRIDs 40042201, 41585101, 43800101
Water Photolysis	3.87 days (pH = 5) (0.179/d)	MRID 40471102
Aerobic Aquatic Half-life (Disulfoton) (K _{baws} , K _{bacs})	12.2 days (0.05682/day)	Estimated per EFED guidance
Aerobic Aquatic Half-life (Total Disulfoton Residues) (K _{baws} , K _{bacs})	259.63 days (2.67E-03/d)	Did not multiple half-life by 2 per EFED guidance to account for uncertainty. Half-lives greater than a year would show residue accumulation.
Foliar Dissipation Rate	3.3 days (0.21/d)	MRID 41201801

¹ Half-lives for total residues were determined from the total residues at each sampling interval. Total disulfoton residues did follow first-order kinetic decay (The slope (decay rate constant, k) of the transformed (natural log or ln) ($\ln C(t) = \ln C_0 - kt$, where C_0 is the initial concentration, C is concentration, and t is time)).

A. Surface Water Drinking Water Assessment with Percent Crop Area and Index Reservoir.

The estimated drinking water concentrations (EDWCs) were evaluated using the methodology outlined in EPA-OPP *draft* Guidance for Use of the Index Reservoir and Percent Crop Area Factor in Drinking Water Exposure Assessments (USEPA, 2000). This generally results in the modification of the scenarios developed for farm ponds to scenarios for the index reservoirs.

The purpose the Index Reservoir (IR) scenario and the Percent Crop Area (PCA) for use in estimating the exposure in drinking water derived from vulnerable surface water supplies. Since the passage of the Food Quality Protection Act (FQPA) in 1997, the Agency has been using the standard farm pond as an interim scenario for drinking water exposure and has been assuming that 100% of this small watershed is planted in a single crop. The Agency is now implementing the index reservoir to represent a watershed prone to generating high pesticide concentrations that is capable of supporting a drinking water facility in conjunction with the percent cropped area (PCA) which accounts for the fact that a watershed large enough to support a drinking water facility will not usually be planted completely to a single crop. These two steps are intended to improve the quality and accuracy of the drinking water exposure for pesticides obtained by models.

Percent Crop Area (PCA): PCA is a generic watershed-based adjustment factor that will be applied to pesticide concentrations estimated for the surface water component of the drinking water exposure assessment using PRZM/EXAMS with the index reservoir scenario. The output generated by the linked PRZM/EXAMS models is multiplied by the maximum percent of crop area (PCA) in any watershed (expressed as a decimal) generated for the crop or crops of interest. Currently, OPP has PCA adjustments for four major crops – corn, cotton, soybeans, and wheat. Two are appropriate for disulfoton, cotton and wheat.

The concept of a factor to adjust the concentrations reported from modeling to account for land use was first proposed in a presentation to the SAP in December 1997 (Jones and Abel, 1997). This guidance results from a May 1999 presentation to the FIFRA Scientific Advisory Panel (SAP), *Proposed Methods For Determining Watershed-derived Percent Crop Areas And Considerations For Applying Crop Area Adjustments to Surface Water Screening Models*, and the response and recommendations from the panel. A more thorough discussion of this method and comparisons of monitoring and modeling results for selected pesticide/crop/site combinations is located at: http://www.epa.gov/scipoly/sap/1999/may/pca_sap.pdf.

The Agency will continue to develop PCAs for other major crops in the same manner as was described in the May 1999 SAP presentation. However, the Agency expects that it will use smaller watersheds for these calculations in the near future. For minor-use crops, the SAP found that the use of PCAs produced less than satisfactory results and advised OPP to further investigate possible sources of error. Thus, for the near term, OPP is not be using PCAs in a crop-specific manner for both major crops that do not yet have PCAs and minor-use crops.

Instead it will use a default PCA that reflects the total agricultural land in an 8-digit Hydrologic Unit Code (HUC). The PCA values used in this assessment are listed in Appendix VII. The OPP guidance document provides information on when and how to apply the PCA to model estimates, describes the methods used to derive the PCA, discusses some of the assumptions and limitations with the process, and spells out the next steps in expanding the PCA implementation beyond the initial crops. Instructions for using the index reservoir and PCA are provided below. Discussion on some of the assumptions and limitations for both the PCA and Index Reservoir are included in the Reporting section. One should note that there is an entry for 'All Agricultural Land' in Appendix VII. This is a default value to use for crops for which no specific PCA is available. It represents the largest amount of land in agricultural production in any 8-digit hydrologic unit code (HUC) watershed in the continental United States.

The unadjusted EDWC (PRZM/EXAMS output) is multiplied by the appropriate PCA for that crop to obtain the final estimated drinking water concentration (EDWC). Note that if Tier 2 modeling is done for an area other than the standard scenario, the PCA would still be applied, since it represents the maximum percent crop area for that particular crop. (As regional modeling efforts are expanded, regional PCAs could be developed in the future.) As an example, for a pesticide used only on cotton, the PRZM/EXAMS estimated environmental concentrations would be multiplied by 0.20. This factor would be applied to the standard PRZM/EXAMS scenario for cotton or any non-standard cotton scenario until such time as regional PCAs are developed.

When multiple crops occur in the watershed, the co-occurrence of these crops needs to be considered (maximum of 0.87). The PCA approach assumes that the adjustment factor represents the maximum potential percentage of a watershed that could be planted to a crop (0.87). If, for example, a pesticide is only used on cotton, then the assumption that no more than 20% of the watershed (at the current HUC scale used) would be planted to the crop is likely to hold true.

The Index Reservoir (IR): Barley, cotton, potatoes, and spring were considered because they represent significant uses, maximum application rates, and are grown in vulnerable regions of the United States. This excludes the Christmas tree use, for which there is not an adequate Tier II scenario. For the PRZM, the input files for each IR scenario are essentially the same as its farm pond scenario. Three parameters in the PRZM input file require modification, AFIELD, HL, and DRF (<http://www.epa.gov/scipoly/sap/1998/index.htm>).

The Tier II modeling results (Table 1) from PRZM/EXAMS fall within the range of parent disulfoton concentrations for surface water reported in a Virginia monitoring study (0.37 to 6.11 $\mu\text{g/L}$) and NAWQA (0.010 to 0.060 $\mu\text{g/L}$). The modeled parent disulfoton concentration estimates are generally greater than those seen in the monitoring data. The modeling results of the degradates correspond reasonably well with those measured at fish kill incident site, but were greater than the detections in the pilot reservoir study. The monitoring data for the disulfoton degradates is extremely limited.

Uncertainty surrounds these estimates because the sites selected for modeling represent sites thought to be representative of vulnerable sites. Additionally, the IR was generic (to each scenario) and data to fully understand of the fate of disulfoton and disulfoton residues is not available. Evidence suggests that the concentrations will not be as high as suggest by the modeled estimates. The PCA values have been estimated by OPP for spring wheat (0.56) and cotton (0.20). The default for value for all agricultural land of 0.87 was used for the barley, potatoes, and tobacco scenarios. Better estimates of the PCA for these crops would reduce the uncertainty associated with the estimated drinking water concentrations.

B. Ground Water Assessment

For this assessment, the maximum rate and number of disulfoton applications were used, while assuming average environmental properties (90 percent upper confidence bound on the mean aerobic soil half-life of 6.12 days and an average K_{oc} value of 551 mL/g). The maximum parent disulfoton concentration predicted in ground water by the SCI-GROW model (using the maximum rate 3 lb. a.i./ac @ 1 applications - potatoes or 1 lb. ai./ac @ 3 applications) was 0.02 $\mu\text{g/L}$. The maximum total disulfoton residue concentration predicted in ground water by the SCI-GROW model is 1.19 $\mu\text{g/L}$ (90 percent upper bound on mean half-life of total residues is 259.6 days).

It should be noted that all the detections of disulfoton residues in ground water in Wisconsin (range 4.0 to 100.0 $\mu\text{g/L}$) and some detections in Virginia (range 0.04 -2.87 $\mu\text{g/L}$) exceeded the concentrations predicted by SCI-GROW (0.02 $\mu\text{g/L}$). Although SCI-GROW, which is thought to be conservative (e.g., a vulnerable site), is based on a regression relationship between monitoring data (detected concentrations) and pesticide fate chemistry at vulnerable sites, SCI-GROW does not account for preferential flow, point-source contamination, pesticide spills, misuses, or pesticide storage sites. Many unknowns, data limitations, such as on-site variability, are also present in the prospective ground-water monitoring studies which were not included when developing SCI-GROW. The difference between monitoring and modeling is discussed further in the next section.

Disulfoton Monitoring Data

Surface Water Monitoring:

Virginia: The previously discussed study to evaluate the effectiveness of Best Management Practices (BMP) in a 3616-acre watershed in the Nomini Creek Watershed, Westmoreland County, Virginia (Mostaghimi, 1989; Mostaghimi et al. 1998) also collected a limited number of runoff and surface water samples at two stations. For more discussion see Ground-Water Section above, and Appendix 1. The results the surface water monitoring for disulfoton parent is presented in Table 6.

Table 6. Disulfoton detections in surface water samples collected in the Nomini Creek Watershed (Virginia), during 1986.

Sample date	Site number: Sample number	Concentration (µg/L)
8/18/86	QN1:1 (9:13 am)	6.11
8/18/86	QN1:2 (12:25 pm)	0.37
9/28/86	QN2: (only 1 sample)	1.62

NAWQA: Disulfoton residues have been detected in surface water at a low frequency in the USGS NAWQA study. The percentage of detections with disulfoton concentrations $>0.01 \mu\text{g/L}$ for all samples, agricultural streams, urban streams were 0.27%, 0.20, and 0.61%, respectively. The corresponding maximum concentrations were 0.060, 0.035, and $0.037 \mu\text{g/L}$. Disulfoton has not been detected in ground water in the NAWQA study. Although pesticide usage data is collected for the different NAWQA study units, the studies are not targeted, specifically for disulfoton.

STORET: About 50 percent of the well samples reported in STORET had low levels ($<1 \mu\text{g/L}$) of disulfoton residues. However, there were indications of some high concentrations (the other 50% were reported as $<250 \mu\text{g/L}$), which may be a reflection of how the data were reported as the disulfoton concentrations in the monitoring were not always known. This is because the detection limit was extremely high or not specified, and/or the limit of quantification was not stated or extremely high. Disulfoton concentrations were simply given as less than a value. Therefore, considerable uncertainty exists with respect to the STORET monitoring data. The STORET data was considered only from a “qualitative” standpoint. EFED considered in the assessment that while one does not know the concentration in the wells reported as disulfoton concentrations $< 1 \mu\text{g/L}$, you know do it is not $>$ than $1 \mu\text{g/L}$.

Ground Water Monitoring:

Monitoring Studies With No Disulfoton Residues Detections in Ground Water: The Pesticides in Ground Water Data Base (USEPA, 1992) summarizes the results of a number of ground-water monitoring studies conducted which included disulfoton (and rarely the disulfoton degradates D. sulfone and D. sulfoxide). Monitoring, with no detections (limits of detections ranged from 0.01 to $6.0 \mu\text{g/L}$), has occurred in the following states (number of wells): AL (10), CA (974), GA (76), HI (5), IN (161), ME (71), MS (120), MN (754), OK (1), OR (70), and TX (188). The range of detection limits, especially the high ones (e.g., $6 \mu\text{g/L}$) reduce the certainty of these data.

One hundred twenty wells were analyzed in MS for disulfoton degradates sulfone and sulfoxide and 188 wells were analyzed in TX for sulfone. Limits of detection were 3.80 and

1.90 µg/L for the sulfone and sulfoxide degrade, respectively, in MS. There were no degradates reported in these samples.

North Carolina: The North Carolina Departments of Agriculture (NCDA) and Environment, Health, and Natural Resources (DEHNR) conducted a cooperative study under the direction of the North Carolina Pesticide Board (NCIWP, 1997). The purpose of the statewide study was to determine if the labeled uses of pesticide products were impacting the ground water resources in North Carolina.

The study was conducted in two phases. In phase one, 55 wells in the DEHNR Ground Water Section's ambient monitoring network representing the major drinking water aquifers of the state were sampled at least twice and analyzed for selected pesticides. In phase two, 97 cooperator monitoring wells were installed and subsequently sampled at least twice in 36 counties across the North Carolina. Sites for the cooperator monitoring wells were chosen based on an evaluation of the vulnerability of ground water to risk of contamination from the use of pesticides.

Monitoring wells were located adjacent to and down-gradient from areas where pesticides were reported to have been applied (within 300 feet) during the previous five years. Wells were constructed so that the shallowest ground water could be collected for analysis. The objective of these criteria was to use a scientific method for determining monitoring well locations so that the results could be used as an early indication of the potential for problems associated with pesticides leaching to ground water. Disulfoton residues were monitored for in five North Carolina counties, Allegheny, Ash, Beaufort, Madison, and Robeson. Seven wells were located in Christmas Tree growing areas, one in wheat growing county, and two in tobacco areas. The study authors make the following statement, *"Results cannot be interpreted as representing the quality of ground water near pesticide use areas statewide because the study methods targeted areas of highly vulnerable ground water"*.

There were no detections of disulfoton, disulfoton sulfoxide, and disulfoton in the ground-water monitoring study conducted in North Carolina. Efforts were made to place the wells in vulnerable areas where the pesticide use was known, so that the pesticide analyzed for would reflect the use history around the well. Limitations of the study include that sites were sampled only twice and the limits of detections were high (e.g., > 1.0 µg/L) for some of disulfoton analytes. Uncertainties associated with the study include whether two samples from eight wells are adequate to represent the ground-water concentrations of disulfoton residues, if DRASTIC correctly identified a site's vulnerability, and if the wells were placed down-gradient of the use areas.

The study used tools and information available at the time of the study to identify vulnerable locations for well placement. This included statewide agricultural data from the N.C. Agricultural Statistics which were used to identify crop growing areas, the USEPA DRASTIC method (Aller et al., 1987) was used to locate the most vulnerable locations in the target crop growing areas, and local county agents of the USDA Natural Resources Conservation Service

(NRCS) helped identify cooperators-farmers for placement of wells. The Pesticide Study staff and county agents also met with the cooperators to obtain pesticide use information. Other studies have shown that DRASTIC is not as good a method to identify vulnerable areas as hoped. The study appeared to QA/QC practices.

Monitoring Studies With Disulfoton Detections in Ground Water: Two of the studies cited in the PGWDB (USEPA, 1992) report the detection of disulfoton residues in ground water. The disulfoton detections in ground water in occurred studies conducted by Virginia Polytechnic Institute and State University (VPI&SU, Mostaghimi, 1989; Mostaghimi et al. 1998) in Virginia where disulfoton concentrations ranged from 0.04 to 2.87 µg/L and in a Wisconsin Department of Natural Resources study in Wisconsin (WDNR, after Barton, 1982) where concentrations ranged from 4.00 to 100.00 µg/L. Of specific are the disulfoton concentrations of parent disulfoton reported in these studies (VA and WI) that exceeded the estimate of 0.02 µg/L obtained from EFED's SCI-GROW (ground-water screening model) model.

Virginia: A monitoring study was conducted to evaluate the effectiveness of Best Management Practices (BMP) in a 3616-acre watershed in the Nomini Creek Watershed, Westmoreland County, Virginia. (A more detailed assessment of the final report of Nomini Creek Watershed BMP study was prepared earlier (11/20/01) in Appendix 1). Approximately half of the watershed is in agriculture and the other half is forested. The major focus of this study was surface-water quality rather than ground-water quality. However, in addition to the surface-water monitoring, twelve wells were analyzed for pesticides, including disulfoton.

Samples were initially taken in 1985 and 1986 from four household wells in the Nomini Creek Watershed (NCW). Water samples from these wells were analyzed for 24 pesticides. Detectable levels of (not specified) pesticides were found in all four wells at concentrations below the respective MCL. One of these four household wells consistently had higher pesticide levels than the other wells. The study authors suggested that this household well was not "sufficiently protected and was contaminated by surface runoff from adjacent land".

Based upon these results of the four household wells sampled, eight pairs of ground-water monitoring wells (39 to 54 feet deep) were installed at eight sites in the NCW and sampled approximately monthly from June 1986 through June 1997. Information concerning farming practices in the watershed was obtained from farmer interviews and questionnaires. Monitoring consisted of two (2) runoff and surface water monitoring stations; seven rain gauges; one weather station; and eight (8) pairs of ground-water monitoring wells. The ground water wells were located primarily in agricultural areas. These wells were drilled in pairs, 100 - 150 meters apart, with one in pair located hydraulically down-gradient of the other. Approximately monthly samples were taken from each monitoring well and analyzed for a number of analytes including 22 pesticides. QA/QC procedures were followed. The mean of all parent disulfoton detections is 0.39 µg/L, the mean of the pre-BMP is 0.52 µg/L, and post-BMP is 0.08 µg/L (Table 7). The maximum detection was 2.87 µg/L. The final report is discussed in Appendix 1.

Table 7. Ground-water parent disulfoton sampling results and detection statistics in the Nomini Creek Watershed (Mostaghimi, 1998).						
Pesticide	Total Samples	Detections	Detection ² Frequency (percent)	Concentration (µg/L)		
				Max	Mean	SD
Disulfoton	1010	10	1.0	2.87	0.39	0.32
	Pre-BMP ³ (5/86 - 10/88)					
	229	7	3.1	2.87	0.52	-
	Post-BMP ⁴ (11/89 - 9/96)					
	693	3	0.4	0.10	0.08	-

¹ Number of samples with detectable levels of pesticide

² (samples with detectable levels of pesticide * 100)/total number of samples

³ Before agricultural Best Management Practice (BMP) implemented in watershed.

⁴ Following the implementation of BMP within the watershed.

Wisconsin: Barton, 1982. In May and June 1982, the Wisconsin Department of Natural Resources (WDNR) sent twenty-nine water samples from wells in the Central Sands area of Wisconsin to the EPA's Office of Pesticide Programs for pesticide residue analysis. Samples were taken from one municipal well, two or three community wells, and twenty-five home wells; all of which were sources of drinking water. Of the 29 samples, 15 samples were reported as no detects whereas 14 samples were reported disulfoton detections. Disulfoton detections ranged from 4.00 to 100.00 µg/L, with a mean (samples with detections) of 38.43 µg/L and standard deviation of 31.56 µg/L. No detection limit was specified for disulfoton, although detections as low as 1 µg/L are reported for other pesticide residues (aldicarb, and aldicarb sulfone, dinoseb, sencor, linuron, carbofuran, and Lasso/Bravo).

Holden (1986) wrote that the WDNR sampling program was criticized for a number of reasons including that the quality assurance and quality control procedures (QA/QC) were not always followed during some stages of sampling and analysis (Holden, 1986). Holden (1986) further indicates that "Harkin et al. (1984) noted in their WIS WRC report *Pesticides in Groundwater beneath the Central Sand Plain of Wisconsin* that some detections of pesticides in initial screening were false positives and were not supported by resampling and reanalysis by more sensitive analytical methods."

Aldicarb and aldicarb sulfone were also found in this study and in follow up studies, while disulfoton was apparently not found in follow-up sampling. Aldicarb is no longer registered for use in Wisconsin.

The criticisms of the WDNR study must, however, be put in some sort of perspective. First, a study that did not follow QA/QC criteria does not and should not automatically mean that

the data is bad or wrong, the detections may be correct (presence and wrong magnitude). Frequently "older" monitoring studies often had problems associated with them, such as QA/QC problems, limited pesticide usage information, and no knowledge about the study area's hydrology. Frequently, studies with QA/QC programs are poorly designed, so that the results may be meaningless. These data were considered in the water assessment, but were not included when deriving the disulfoton concentrations (EDWCs) for human health assessment.

Pesticide residues not being found in follow-up sampling may be the result of dissipation processes and should not be used to discount detections in earlier samples. The environmental fate properties and site hydrology must also be considered. Because ground water is a dynamic system, pesticides may be present at one sampling event and not at another. So when the sample is collected, in relationship to pesticide use and rainfall, is important. All that can be said is that residues were not found in follow-up samples. It is unknown which samples were re-analyzed with more sensitive methods.

The disulfoton detections in the Central Sand Plain may have been the result of preferential flow and transport processes. Literature documents preferential flow in the Central Sand Plain. Thus, disulfoton residues may have by-passed the soil matrix and gone directly to ground water which is possibly reflected in the "high" level of the detections. Although preferential flow is currently an ongoing area of research and much remains unknown, it is known that preferential flow is influenced by a number of factors, including rainfall amounts, intensity, and frequency. Disulfoton generally appears to be not very persistent under aerobic soil conditions and therefore may also not be very persistent in aquifers that are aerobic. Therefore it may have also been missed by utilizing a predetermined sampling schedule (e.g., monthly). Whereas a persistent chemical, such as aldicarb and aldicarb sulfone, will be found at greater frequencies and be less dependent upon timing of sampling. Disulfoton usage history before the detections and prior to the follow-up sampling is not specified.

Additional Monitoring Without Disulfoton Detections

OPP's EFED contacted individuals in nearly all the states concerning whether organophosphate (OP) pesticides had been sampled for in their state as part of the cumulative OP assessment (http://www.epa.gov/pesticides/cumulative/pr-a-op/iii_e_3-f.pdf). The following presents the survey of states conducted by EFED for the cumulative OP assessment with respect to disulfoton, disulfoton sulfone, and disulfoton sulfoxide. Florida, did not include disulfoton or disulfoton degradates, but is included because the sulfone and sulfoxide degradates of the OP fenamiphos was included. EFED has not evaluate whether any of the monitoring studies noted below were also included in those reported in the PGWDB (USEPA, 1992).

Florida

Over 20,000 "determinations" were made for OPs in several Florida ground-water monitoring programs. Only wells with detections are reported, both for fenamiphos sulfoxide.

This is a large dataset, and it will require more conversations with Florida to understand the full significance of these data.

Continued monitoring in the Lake Ridge monitoring program includes fenamiphos and transformation products fenamiphos sulfoxide and sulfone. These have not been detected in quarterly sampling of monitoring wells in 11 to 33 wells over the last two years.

Hawaii

Robert Boesch of the Department of Agriculture described a drinking-water study conducted this past March. In preparation for the OP risk assessment, Hawaii sampled 36 drinking-water wells in areas where OPs are used on pineapples, or for urban use. These water supply wells, which have shown contamination for other organic chemicals, did not have detections (LOD 0.5 ppb) of the following OPs: acephate, azinphos methyl, chlorpyrifos, DDVP, demeton, diazinon, dimethoate, disulfoton, ethoprop, fenamiphos, malathion, methidation, methyl parathion, mevinphos, monocrotophos, naled and parathion.

Kansas

Theresa Hodges of the Kentucky Department of Health and Environment reports that of the OPs, only diazinon has been detected in their routine ambient surface water quality sampling network. While diazinon is not on the list of pesticides routinely included, it was added because it had been detected. Since 1995, 44 detections were found at 16 urban or golf course sites. The range of detections was from 0.19 to 1.5 micrograms/liter.

Dale Lambley of the Kansas Department of Agriculture sent information on their ground-water monitoring of chemigation wells. The objective of the study “is to assess and monitor groundwater quality by obtaining water samples at selected chemigation sites located at agricultural irrigation wells.” In sampling from 1987 to 2000, chlorpyrifos was detected three times at concentrations of 1.9, 3.5 and 4.2 ppb (LOD = 0.5 µg/l). Dimethoate, disulfoton and methyl parathion were included in sampling, but were not detected above detection levels of 2.0, 0.5 and 1.0 µg/l, respectively.

The 100 samples taken annually are apportioned among five Groundwater Management Districts based on the number of registered chemigation sites in each. Highest priority is given to finding active chemigation sites. Ranking of wells has also been based on proximity to public water supplies (within 3 miles), depth to water, soil type, and whether chemigation misuse is suspected.

Kentucky

Peter Goodman reports that the following OPs are included in their ground-water monitoring program: acephate, chlorpyrifos, diazinon, disulfoton, ethoprop, malathion, methyl parathion and

terbufos. Each was included in more than 1300 analyses from over 300 wells, but only diazinon, chlorpyrifos and malathion were detected.

Maryland

Rob Hofstedter of the Maryland Department of Agriculture reports that their agency has a current ground-water study that includes diazinon. Results of this study are not yet available. He referred me to the Maryland Geological Survey for information on previous surface-water studies which included malathion.

David Bolton of the Maryland Geological Survey provided summary tables from the MGS Report of Investigations number 66, "Ground-Water Quality in the Piedmont Region of Baltimore County, Maryland." Analysis in this rural region included 12 OPs, 10 of which are still registered. Disulfoton was not detected in ground water. Results of the monitoring are as follows, which concentrations in $\mu\text{g/l}$.

Pesticide	# samples	MRL ¹	\geq MRL	<MRL	Maximum Conc.
Disulfoton	112	0.017	0	0	

¹MRL = Minimum Reporting Limit

Michigan

Mark Breithart of the MDEQ Drinking Water Division examined their database, and found that analysis was done for the following OPs in Michigan drinking water: azinphos methyl, chlorpyrifos, diazinon, dimethoate, disulfoton, fenamiphos, malathion, and methyl parathion

None of these were detected in 49 analyses of public water supplies. Of the 421 analyses from private water supplies, only dimethoate was detected. This single detection of 2 micrograms/liter occurred at an aerial spray service, and therefore it is not clear if it was the result of a point source.

Nebraska

Nebraska maintains the "Quality-Assessed Agricultural Contaminant Database for Nebraska Ground Water," which was created from ground water quality data submitted by many organizations." There were no disulfoton detections in 185 analyses. The following OPs are included in the database: chlorpyrifos, diazinon, ethion, malathion, methyl parathion, phorate, and terbufos. The levels of detection are generally below 1 ppb.

Mr. John Lund, supervisor in the Surface Water Unit of the Nebraska Department of Environmental Quality, indicated that OPs have not been included in the State's surface-water monitoring.

North Carolina

Dr. Henry Wade described the “Interagency Study of the Impact of Pesticide Use on Ground Water in North Carolina,” which took place between 1991 and 1995. Sampling of mostly shallow monitoring wells was performed based on information by farmers on which pesticides they used within 300 feet of the wells. By the end of the study, more than 240 pesticides were included as analytes.

Sixteen OPs were included in the analysis, but none were detected. The number of wells sampled for each OP is shown below: acephate (23 wells), azinphos-methyl (7), chlorpyrifos (25), diazinon (8), dimethoate (5), disulfoton (12), ethoprop (6), fenamiphos (4), fonofos (1), malathion (9), mevinphos (1), parathion (5), phorate (3), phosmet (2), terbufos (13) and trichlorfon (2).

Other pesticides were detected in these wells, especially herbicides. The main focus of the study was herbicides which the EPA had identified as “potential leachers.”

West Virginia

Doug Hudson of the WV Department of Agriculture says that West Virginia DoA does intermittent ground water sampling, including an OP screen. He could recall only a single detection of diazinon, which they could not confirm. Other OP detections in ground water were in response to improper termiticide use.

Chad Board of the DEP sent a spreadsheet with analytical results which included the following OPs: chlorpyrifos, diazinon, disulfoton, ethoprop, malathion, phorate, and terbufos. Each were sampled in 12 wells, but not detected. The detection limits ranged from 0.005 to 0.027 ppb.

Wisconsin

Bill Phelps, of the Wisconsin Department of Natural Resources Bureau of Drinking & Groundwater provided a summary of monitoring Wisconsin has done in public and private water supply wells and information on monitoring from their GEMS database performed at regulated/investigated sites. The detections of disulfoton occurred at a pesticide formulation plant - thus this would be a point source rather than non-point source normal use.

Analyte	# Water Supply Wells	# Detects in Water Supply Wells	#GEMS wells	# GEMS wells with detections	Maximum concentration detected (ug/l)
disulfoton	0		190	9	240

Wyoming

Jim Bigelow of the Wyoming Department of Agriculture described the generic Pesticide Management Plan ground-water program, which includes a network of 178 wells. A total of 54 active ingredients are included as analytes, including eight active OPs: azinphos-methyl, chlorpyrifos, diazinon, disulfoton, malathion, methyl parathion, phorate and terbufos.

Ms. Miller indicated that there have been detections of pesticides in 117 of 178 wells. The Agency will investigate further details of this monitoring program.

Limitations of Monitoring Data

The interpretation of the monitoring data is limited by the lack of correlation between sampling dates and the use patterns of the pesticide within the study's drainage basin. Additionally, the sample locations were not associated with actual drinking water intakes for surface water nor were the monitored wells associated with known ground water drinking water sources. Also, due to many different analytical detection limits, no specified detection limits, or extremely high detection limits, a detailed interpretation of the monitoring data is not always possible.

Limitations for the monitoring studies include the use of different limits of detection between studies, lack of information concerning disulfoton use around sampling sites, and lack of data concerning the hydro geology of the study sites. The spatial and temporal relationship between disulfoton use, rainfall/runoff events and the location and time of sampling cannot often be adequately determined. Thus, it is not always possible to judge the significance of the level or the lack of detections.

Although no assessment can be made for degradates due to lack of monitoring data, limited data suggests that the degradates are more persistent (>200 days) than disulfoton, suggesting their presence in water for a longer period of time than the parent. The degradates also appear to be more mobile than the parent compound.

vii. Limitations of this Modeling Analysis

There are number of factors which limit the accuracy and precision of this modeling analysis including the selection of the high-end exposure scenarios and maximum number of applications and rates, the quality of the data, the ability of the model to represent the real world, and the number of years that were modeled. There are additional limitations on the use of these numbers as an estimate of drinking water exposure. Individual degradation/metabolism products were also not considered due to lack of data. Another major uncertainty in the current EXAMS simulations is that the aquatic degradation rate used an estimated rate due to lack of data. Direct aquatic photolysis was also included. The total disulfoton residue decline rate was estimated from data, but K_{oc} s and hydrolysis rates for D. sulfoxide and D. sulfone were not known and assumed to be equal to those of parent disulfoton. These limitations influence the estimates of

pesticides transported off the field (loading files) to the reservoir, plus the degradation once in the reservoir.

Spray drift is determined by method of pesticide application, and is assumed to be 0% percent when applied as broadcast (granular) or in-furrow, and 6.4% ground and 16.4% aerial spray for the Index Reservoir scenario (Jones et al., 2000).

The Tier II scenarios are also ones that are likely to produce high concentrations in aquatic environments. The scenarios were intended to represent sites that actually exist and are likely to be treated with a pesticide. These sites should be vulnerable enough to provide a conservative estimates of the EDWC, but not so vulnerable that the model cannot properly simulate the fate and transport processes at the site. The EDWCs in this analysis are accurate only to the extent that the sites represent the hypothetical high exposure sites.

The quality of the analysis is also directly related to the quality of the chemical and fate parameters available for disulfoton. Acceptable data are available, but rather limited (minimal) or not available for the degradates. Data were not available for degradates and the aquatic aerobic metabolism rate was not known, but estimated. Degradates with greater persistence and greater mobility would be expected to have a higher likelihood of leaching to ground water, with greater concentrations in surface water. The measured aerobic soil metabolism data is limited, but has sufficient sample size to establish an upper 90% confidence bound on the mean of half-lives for the three aerobic soils tested in the laboratory (and submitted to EFED) and reported in the EFED One-liner Database (MRIDs 40042201, 41585101, 43800101). The use of the 90%-upper bound value may be sufficient to capture the probable estimated environmental concentration when limited data are available. PRZM assumes pesticide decline follows first-order kinetics. As discussed in the aerobic soil metabolism section of the disulfoton RED, disulfoton doesn't entirely follow first-order kinetics.

The models themselves represent a limitation on the analysis quality. These models were not specifically developed to estimate environmental exposure in drinking water so they may have limitations in their ability to estimate drinking water concentrations. Another limitation is the lack of field data to validate the predicted pesticide run-off. Although, several of the algorithms (volume of run-off water, eroded sediment mass) are somewhat validated and understood, the estimates of pesticide transport by PRZM3 has not yet been fully validated. Other limitations of PRZM are the inability to handle within site variation (spatial variability), crop growth, and the overly simple water balance. Another limitation is that 20 to 40 years of weather data were available for the analysis. Consequently there is a 1 in 20, 27, 36, or 40 chance that the true 10% exceedence EDWCs are larger than the maximum EDWC in the analysis. If the number of years of weather data were increased, it would increase the level of confidence that the estimated value for the 10% exceedence EDWC was close to the true value.

EXAMS is limited because it is a steady-state model and cannot accurately characterize the dynamic nature of water flow. A model with dynamic hydrology would more accurately reflect concentration changes due pond overflow and evaporation. Thus, the estimates derived

from the current model simulates a pond having no-outlets, flowing water, or turnover. Another major limitation in the current EXAMS simulations is that the aquatic (microbial) and abiotic degradation pathways were adequately considered. Disulfoton and the sulfone and sulfoxide degradates were considered as total disulfoton residues. The binding potentials of the degradates were not known (they were not considered individually), but were assumed to be the same as parent disulfoton.

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Note: All states contacted are listed below. Only the states which monitored for disulfoton (except Florida) are include in this document.

Monitoring contacts

Tony Cofer, Pesticide Administrator of the Alabama Department of Agriculture and Industry
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Dr. Enid Probst , Alabama Department of Environmental Management

Rose Lombardi , Alaska Department of Environmental Conservation Pesticide Program
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Cheryl Eddy Miller, United States Geological Survey, Wyoming

Robert Sneed, United States Army Corps of Engineers

APPENDIX 1.

**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460**

**OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES**

TO: Christina Scheltema
Betty Shackleford
Michael Goodis
Special Review and Reregistration Division (7508C)

FROM: James Wolf
ERB3
Environmental Fate and Effects Division (7507C)

DATE: November 20, 2001

RE: Disulfoton residues in ground water found in the Virginia BMP Study:

BMP Impacts on Nitrate and Pesticide Transport to Groundwater in the Nomini Creek Watershed. Final Report No. NC-0298

S. Mostaghimi, S. Shukla, and P. W. McClellan. 1998.
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- The ground water monitoring component was started in 1986 and ended in June, 1997.
- Nomini Creek Watershed is located in Westmoreland County, Va. The 1463 ha watershed has typical Coastal Plain land use 49% cropland, 47% woodland, and 4% used for homestead and roads (different reports has slightly different breakdown, but have the same major uses). Average annual precipitation is 102 cm, with most of the rainfall occurring between April and September. Most ground water recharge occurs in late Fall or early spring.
- Nomini Creek Watershed is located in the Coastal Plain Physiographic providence. Soils, geology and topography are similar to the of the unglaciated Atlantic Coastal Plain. Soils are mostly Ultisols. The major soil series are Suffolk and Rumford. These soils cover 91 percent of the area and have similar physical properties.

Soil	Taxonomy
Sulfolk	Coarse-loamy, siliceous, thermic Typic Hapudults
Rumford	Coarse-loamy, siliceous, thermic Typic Hapudults

The Coastal Plain has been identified as a vulnerable area to ground water contamination. Other vulnerable regions have also been identified. The soils could also be used to identify possible problem areas. (Can't be done by tomorrow). These are vulnerable soil for leaching.

- Agriculture is primarily row crops. Major crops are corn, soybeans, and small grains (wheat and barley). Typical rotation is conventionally-tilled corn, followed by small grains with no-till soybeans planted in the small grain residues. Occasionally, full season, conventionally-tilled soybeans is also grown. USDA Ag Statistics do not report

tobacco production for Westmoreland County. Potatoes are reported to be produced, but production appears to be declining.

- Study Objective to study the quality of surface and ground water as influenced by the agricultural practices in the watershed.
- Monitoring consisted of two (2) runoff and surface water monitoring stations; seven rain gauges; one weather station; and eight (8) ground-water monitoring wells (GN1 to GN8). The ground water wells were located primarily in agricultural areas. These wells were drilled in pairs, 100 - 150 meters apart, with one in pair located hydraulically down-gradient of the other.

Characteristic (m)	Value	Well							
		GN1	GN2	GN3	GN4	GN5	GN6	GN7	GN8
Well depth		13.7	12.8	15.2	13.7	16.5	12.0	15.8	11.9
GW depth	Mean	10.3	9.6	13.1	9.4	12.9	8.2	13.3	8.6
“	Max.	12.0	10.8	14.0	12.7	13.9	9.1	14.4	9.6
“	Min	8.5	7.1	11.5	7.0	11.3	7.0	11.8	7.4

- Approximately monthly samples were taken from each monitoring well and analyzed for a number of analytes including 22 pesticides. QA/QC procedures were followed.
- Herbicide and insecticide application information in the watershed were obtained from farmer surveys. The rate and time of herbicide application was dependent on the crop rotation adopted by the farmer. Corn is usually planted between late April and early May. Post-emergence sprays applications occur in early July. The timing and application rates of insecticides, applied individually or in combination, in the watershed depending on the type and extent of the insect problem observed.

Note: the label does allow for fall application to wheat. Perhaps fall application and greater fall recharge resulted in the observed concentration (2.87 µg/L). Possible mitigation option?

- Disulfoton sampling results and detection statistics in the Nomini Creek Watershed (Table 15, after Mostaghimi, 1998). These are disulfoton parent.

Pesticide	Total Samples	Detections	Detection ² Frequency (percent)	Concentration (µg/L)		
				Max	Mean	SD
Disulfoton	1010	10	1.0	2.87	0.39	0.32

	Pre-BMP ³ (5/86 - 10/88)					
	229	7	3.1	2.87	0.52	-
	Post-BMP ⁴ (11/89 - 9/96)					
	693	3	0.4	0.10	0.08	-

¹ Number of samples with detectable levels of pesticide

² (samples with detectable levels of pesticide * 100)/total number of samples

³ Before agricultural Best Management Practice (BMP) implemented in watershed.

⁴ Following the implementation of BMP within the watershed.

Note: I only had (raw) data through 1990. Thus, I only had 6 of the 10 detections, mean was 0.57 µg/L, which is only slightly greater than the mean with 7 samples (pre-BMP).

Discussion and recommendation:

The following table was included in Feb. 7, 2000 Additional Clarification of Disulfoton Ground-Water Monitoring Data Assessment. In a recent discussion about a “chronic” exposure for ground water the following suggestions was put forth (mean = $1.49 \mu\text{g/L} = (2.87 + 0.1)/2$ for well site GN3. Considering there are many “monthly samples, with most being less than the detection limit, a lower mean is probably justified (disulfoton parent only). The mean of all the detections is $0.39 \mu\text{g/L}$, the mean of the pre-BMP is $0.52 \mu\text{g/L}$, and post-BMP is $0.08 \mu\text{g/L}$. Without specifically estimating a concentration, I think that as far as parent disulfoton goes, the average concentration would be expected to be considerably less than the DWLOC of 1.2(?).

Summary of Disulfoton Detections in ground water from the eight ground-water monitoring wells in Nomini Creek Watershed (Virginia), during 1986 and 1987.

Sampling Date	Well-Site Number	Concentration (µg/L)
11/5/86	GN3	2.87
11/5/86	GN6	0.04
3/13/87	GN4	0.10
8/20/87	GN1	0.13
8/20/87	GN2	0.16
8/20/87	GN3	0.10